Age estimation using the maxillary canine pulp/tooth ratio in Korean adults: A CBCT buccolingual and horizontal section image analysis

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A B S T R A C T

Various age estimation approaches have been proposed in dental clinic, and it is necessary to have a simple, easy, fast and conservative method that can be applied to living individuals. In this study, an age estimation model was established by measuring the change in the pulp/tooth ratio that occurs due to the progression of pulp calcification associated with aging. This was done using CBCT to image the buccolingual and horizontal dimensions of the maxillary canine. Two hundred and five clinical CBCT images (age range: 20–77 years) were analyzed. In this study, we used the largest pulp/tooth area (S, sagittal pulp/tooth area ratio %) on the buccolingual sectional image in order to overcome the limitations of using a superimposed image in 2D. In addition, horizontal section images were obtained from the CEJ (HC, horizontal pulp/tooth area ratio % on CEJ) and 1/2 of root length (HA, horizontal pulp/tooth area ratio % on mid-root) positions, where the greatest degree of calcification takes place. The pulp/root area ratios were calculated from these images using a numerical analysis software. According to the resultant age estimation model, age can be estimated. This method uses the largest buccolingual and horizontal sectional CBCT canine images without image distortion. Buccolingual sectional image (S) is the largest predictor variables (36.4%) compared to HC (29.7%) and HA (22.4%). This model involves the use of a numerical analysis software, which is quick and easy to use, because it calculate pulp and tooth area by semi-automatic.

1. Introduction

Age estimation of deceased individuals is useful to establish identity in cases that involve crime, major accidents, or other severe circumstances. Teeth in forensic science are advantageous because they can be preserved in large fires or in other cases of extreme external stress, and they can be preserved for a long period of time in situations involving rigor mortis and decomposition. Especially, canine has the longest root, so it shows survival rate.

For adults with complete permanent dentition, a method has been reported by Kambe et al. that measures the degree of attrition from a dental cast model [1]. However, in the case of bruxism, there could be a great error in age estimation due to a higher attrition level than would be expected from one's age. Moreover, work in an occupation that uses acids that induce dental erosion is an environmental factor that exacerbates errors in estimation. Cameriere et al. introduced an age estimation method that uses radiographs (intraoral periapical and panoramic radiographs) in order to eliminate the effects of these habits and occupational environments [2–5]. The pulp/tooth ratio described by Cameriere et al. can be used for age estimation because pulp tissue becomes calcified with age, and this results in a decrease in the proportion of pulp cavity area compared to the area of the entire tooth [6]. Azevedo et al. also used panoramic and peri-apical radiographs of the canine to measure pulp/tooth area ratio [7]. However, in previous studies, it has error potential that can arise due to a 3-dimensional body being projected onto two dimensions. This can result in image distortions such as superimposed or rotated teeth. And previous studies using conventional two-dimensional radiographic images which were measured pulp/tooth ratio on mesiodistal view, On the other hand buccolingual view reflect the largest area on tooth,
mesiodistal view does not [11–11]. Several researchers estimated age by using three-dimensional cone-beam CT to overcome this limitation [12–19]. This study proposes a useful method for age estimation that relies on measurements of the pulp/tooth ratio taken from the horizontal view of the cemento-enamel junction (CEJ) and the root 1/2 portion. These areas are where the highest level of calcified precipitation occurs. In addition, using CBCT to measure the buccolingual section, the widest part of the tooth on the long axis, could solve the problems caused by traditional two-dimensional radiographs.

The purpose of this study was to use the buccolingual sectional image of the maxillary canine for age estimation and to establish an age estimation model from CBCT buccolingual and horizontal sectional images using a numerical analysis software in the Korean population (age range: 20–77 years).

2. Materials and methods

2.1. Subjects

Two hundred and twenty-four Korean patients (115 female, 109 males; mean age: 45.7 ± 15.8 years; age range: 20–77 years) with CBCT data (CS 9300, Carestream Health, Rochester, NY) (Table 1) were enrolled in this study. These subjects were selected from the population of patients who visited 0000 hospital between January 2014 and December 2015. The CBCT images used in this study were taken for the purpose of routine therapeutic treatment and clinical evaluation. Therefore, informed consent was not required. Patients were excluded who showed abnormal tooth size or shape resulting from oral and maxillofacial deformities Patients with internal or external resorption of tooth due to orthodontic treatment or trauma, and patients with disorders that affect the pulp/tooth area, such as cysts or tumors, were also excluded. This study was reviewed and approved by the Institutional Review Board of 0000 Hospital (E-2016015).

2.2. CBCT image acquisition for maxillary canine

The right maxillary canine, which has the longest root and the longest remaining rate in the oral cavity, was selected for measurement in each subject. Cone-beam CT images were taken under following settings: 10 mA (tube current), 90kVp, 10.8 s (exposure time), 15.1×15.1 cm (field of view), 753×753 dimension, 0.2 mm slice thickness, 0.2 mm resolution. In order to obtain the maxillary canine image, OnDemand3D (Cybermed Co., Seoul, Korea) was used with the following image settings: window width 4000, window level 1500.

2.3. Buccolingual and horizontal sectional images of the maxillary canine (#13)

Buccolingual sectional images were obtained by the following process (Fig. 1):

First, set the long axis of the upper right canine (#13) from canine tip to root apex.
Second, adjust the buccolingual plane at axial view which was the most convex point of the buccal crown (S, sagittal pulp/tooth area ratio % = pulp area/tooth tooth area×100).
Horizontal sectional images were obtained by the following process: Following the long axis of the upper right canine, set the horizontal plane to the cementoenamel junction (CEJ) (HC, Horizontal pulp/tooth area ratio % on CEJ=pulp area/tooth tooth area×100).
In addition, a root 1/2 (HA, Horizontal pulp/tooth area ratio % on mid-root=pulp area/tooth tooth area×100) image between CEJ and the root apex was obtained.

![Fig. 1. Buccolingual image of the sagittal view of the maxillary right canine obtained by CBCT. a) coronal view of the maxillary right canine, b) sagittal view of the maxillary right canine, c) horizontal view of the maxillary right canine. d) 3D front image of analysis subject.](image-url)
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